10.4 Economic Models of Environment Issues

Privately Owned Resources

We will review some common economic models of the environment. In each model, the market's failure to account for environmental externalities is the exception rather than the rule, and neoclassical theory is then applied in order to cure or circumvent an inefficiency.[32] Neoclassical theory has been applied to environmental issues to determine what conditions are necessary for the efficient allocation of resources and how market failures lead to inefficiencies and to suggest ways in which these distortions can be corrected.

Figure 10.1 demonstrates how the market determines the optimal consumption of a natural resource. Finding the optimal market outcome involves maximizing the total net benefits to society from a resource, which is the difference between the total benefits derived from a resource and the total costs to producers of providing it. This is equal to the shaded area in Figure 10.1. **Total net benefit** is maximized when the **marginal cost** of producing or extracting one more unit of the resource is equal to its marginal benefit to the consumer. This occurs at Q^*, where the demand and supply curves intersect. In a perfectly competitive market, the "invisible hand" will ensure that Q^* is the quantity produced. The marginal cost curve in Figure 10.1 is upward-sloping because extraction costs increase as a resource becomes more scarce. The resulting **producer surplus** is area *aPb*, and the **consumer surplus** is area *DPb*. Together they yield a maximum net benefit equal to *Dab*.

If resources are scarce and are rationed over time, **scarcity rents** may arise; these may obtain even when the marginal cost of production is constant, as in Figure 10.2. The owner of a scarce resource has a finite volume of a resource *X*

Total net benefit The sum of net benefits to all consumers.

Marginal cost The addition to total cost incurred by the producer as a result of increasing output by one more unit.

Producer surplus Excess of what a producer of a good receives and the minimum amount the producer would be willing to accept because of a positive-sloping marginal cost curve.

Consumer surplus Excess utility over price derived by consumers because of a negative-sloping demand curve.

Scarcity rent The premium or additional rent charged for the use of a resource or good that is in fixed or limited supply.

FIGURE 10.1 Static Efficiency in Resource Allocation

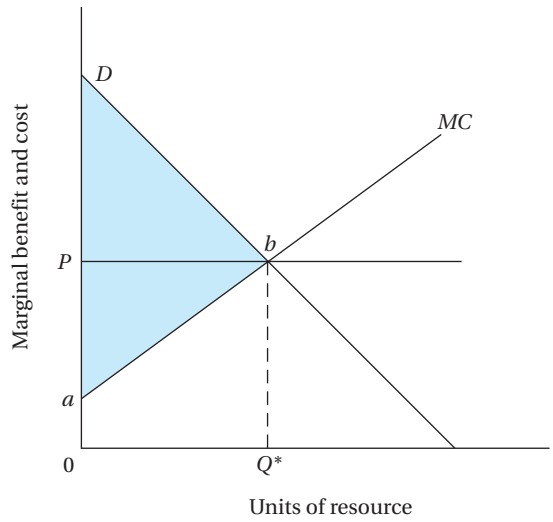
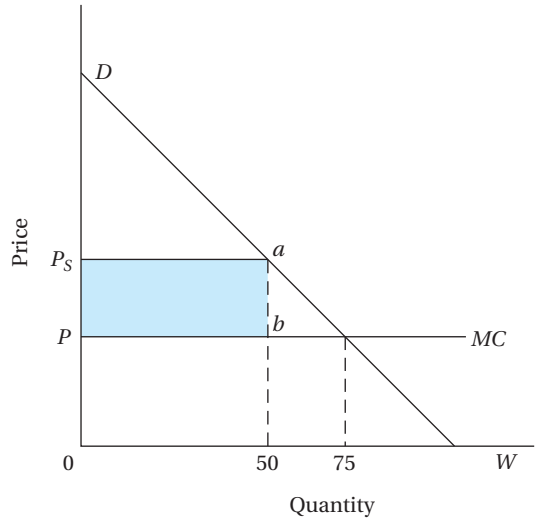


FIGURE 10.2 Optimal Resource Allocation over Time



to sell (75 units) and knows that by saving a portion of it for future sales, he or she can charge a higher price today. The price of a good that is being rationed intertemporally (over time) must equate the **present value** of the **marginal net benefit** of the last unit consumed in each period. That is, the consumer must be indifferent between obtaining the next unit today and obtaining it tomorrow. In Figure 10.2, assume that a resource owner has 75 units available. If he or she is willing to offer only 50 units for sale today, the market price for the scarce resource is P_s. The scarcity rent collected by the owner of the resource is equal to $P_s abP$, the shaded region in the diagram between price and marginal cost. It is the owner's ability to collect this rent that creates the rationing effect to ensure the efficient allocation of resources over time. In the absence of scarcity, all of the resource will be sold at the extraction cost $P = MC$, 75 units will be consumed at one time, and no rent will be collected.

Present value The discounted value at the present time of a sum of money to be received in the future.

Marginal net benefit The benefit derived from the last unit of a good minus its cost.

The proponents of neoclassical free-market theory stress that inefficiencies in the allocation of resources result from impediments to the operation of the free market or imperfections in the property rights system. So long as all resources are privately owned and there are no market distortions, resources will be allocated efficiently. Perfect **property rights** markets are characterized by four conditions:

Property rights The acknowledged right to use and benefit from a tangible (e.g., land) or intangible (e.g., intellectual) entity that may include owning, using, deriving income from, selling, and disposing.

1. *Universality*—all resources are privately owned.
2. *Exclusivity* or "excludability"—it must be possible to prevent others from benefiting from a privately owned resource.
3. *Transferability*—the owner of a resource may sell the resource when desired.
4. *Enforceability*—the intended market distribution of the benefits from resources must be enforceable.

Under these conditions, the owner of a scarce resource has an economic incentive to maximize the net benefit from its sale or use. For example, a farmer who owns his land will choose the levels of investment, technology, and output that maximize the net yield from the land. Because the value of the land may be used as collateral, any viable farm investment can be financed by obtaining a loan at the prevailing market rate of interest.

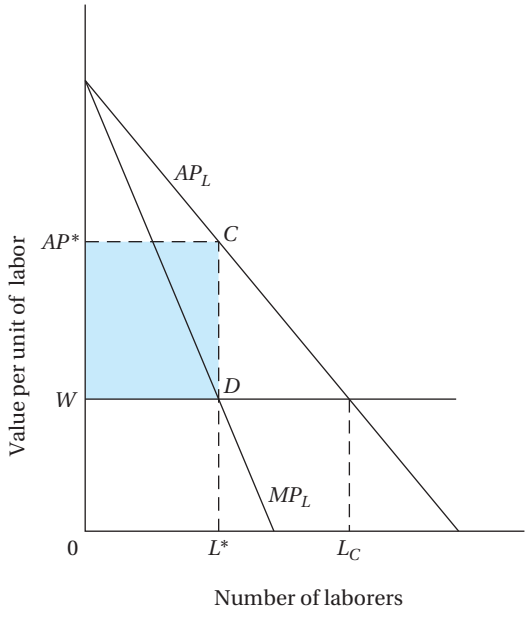
If the foregoing conditions are not met simultaneously, inefficiencies are likely to arise. Thus the way to correct the misallocation of resources is generally to remove any market distortions. A number of models have been designed to explain apparent inefficiencies in resource allocation and to evaluate alternative remedies. We next look at two simple models of inefficiency arising from imperfections in property markets.

Common Property Resources

If a scarce resource (such as arable land) is publicly owned and is freely available to all (for, say, farming or grazing animals), as is the case with a **common property resource**, any potential profits or scarcity rents will be competed away (unless efficient social conventions are binding, as will be discussed shortly). As we have noted, neoclassical theory suggests that in the absence of scarcity rents, inefficiencies will arise. Using a somewhat different framework, we will investigate the misallocation of resources under a common property system. Figure 10.3 describes the relationship between the value per unit of labor on a given piece of land and the number of laborers cultivating it.

Common property resource A resource that is collectively or publicly owned and allocated under a system of unrestricted access, or as self-regulated by users.

FIGURE 10.3 Common Property Resources and Misallocation



Suppose for the moment that this piece of land is privately held. Conventional wisdom tells us that the landowner will hire additional labor to work the land until the marginal product of the last worker is equal to the market wage, W, at point L^*. The workload is shared equally among the employees, each of whom produces the *average* product. However, assuming decreasing returns to labor, each new worker hired reduces the average product of all workers. The *marginal* product of each additional worker is thus equal to his average product minus the decrease in the average product across all other workers. If an additional employee is hired beyond L^*, his cost to the producer, W, will be greater than his marginal product, and the difference will represent a net loss to the landowner. A profit maximizer will thus hire L^* workers, with a total output equal to average product AP^* multiplied by the number of workers, L^*. Scarcity rents collected by the landowner will equal AP^*CDW.

Society's total net benefit from land will be lower under a system of common property unless workers can coordinate their resource use decisions in a cooperative manner. Generally, if land is commonly owned, each worker is able to appropriate the entire product of his work, which is equal to the average product of all workers. Worker income will continue to exceed the wage until enough workers are attracted so that the average product falls to the level of the wage, at which point the labor force equals L_C. Though total output may either rise or fall (depending on whether MP_L is positive or negative—it is negative as drawn in Figure 10.3), the marginal product of the additional workers is below the wage. Because we are assuming that all workers could be employed elsewhere with productivity equal to or greater than W, it follows that social welfare must fall when marginal product falls below W. This situation is sometimes referred to as the "tragedy of the commons." No scarcity rent is collected at L_C. The implication of the common property resource model is that where possible, privatization of resources will lead to an increase in aggregate welfare and an efficient allocation of resources.

Note that these neoclassical models are strictly concerned with efficiency and do not address issues related to equity. Income distribution is not considered, and the theory is unconcerned with the distributional issues arising when all scarcity rents from national resources accrue to a few private owners. Although neoclassical theorists have sometimes suggested that an optimal outcome may be achieved through the taxation and then "lump sum" redistribution of the gains accruing to the owners of scarce natural resources, the historical record for such efforts is not encouraging. This is especially true where the authorities responsible for legislating and coordinating such redistributions are also the owners. Thus the large-scale commercial privatization of resources does not necessarily ensure an improvement in standards of living for the impoverished majority.

There are a number of additional reasons why individuals making use of publicly owned resources may make inefficient use of them within the context of farming systems in developing countries. Family farmers, who, as noted in Chapter 9, are generally the most efficient cultivators of land, may be reluctant to make land-augmenting investments if they are afraid of losing tenure on the common property plot. They may also have insufficient funds to hire additional labor or purchase complementary resources due to a lack of collateral, a

factor that frequently excludes the poor from competitive credit markets (see Chapter 15). It is therefore possible that conferring extended tenancy rights or ownership of land to family farmers would raise productivity. The relevant question for the property rights structure is then, who should obtain title to the land if privatization is to occur? A simple auction of publicly owned land to the highest bidder is unlikely to be consistent with development objectives.

Elinor Ostrom, the 2009 Nobel laureate in economics, discovered that under some conditions, a fair and efficient management of common property can be achieved by the people who depend on it. She and other researchers have also found thousands of historical and contemporary examples where this is achieved in practice. Out of this experience she drew out the "design principles" found in Box 10.2. Traditional societies have often been successful at

BOX 10.2 FINDINGS Elinor Ostrom's Design Principles Derived from Studies of Long-Enduring Institutions for Governing Sustainable Resources

Elinor Ostrom, 2009 Nobel laureate in economics, has summarized findings from research on common property resource management, in the form of eight conditions facilitating fair and efficient management of common property by those who depend upon it. These are:

Clearly defined boundaries. The boundaries of the resource system (e.g., irrigation system or fishery) and the individuals or households with rights to harvest resource units are clearly defined.

Proportional equivalence between benefits and costs. Rules specifying the amount of resource products that a user is allocated are related to local conditions and to rules requiring labor, materials, and money inputs.

Collective-choice arrangements. Many of the individuals affected by the harvesting and protection rules are included in the group who can modify these rules.

Monitoring. Monitors, who actively audit biophysical conditions and user behavior, are at least partially accountable to the users or are the users themselves.

Graduated sanctions. Users who violate rules are likely to receive graduated sanctions (depending on the seriousness and context of the offense) from other users, from officials accountable to these users, or from both.

Conflict resolution mechanisms. Users and their officials have rapid access to low-cost, local arenas to resolve conflicts among users or between users and officials.

At least minimal recognition of rights to organize. The rights of users to devise their own institutions are not challenged by external governmental authorities, and users have long-term tenure rights to the resource.

For resources that are parts of larger systems: Nested enterprises. Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises.

Ostrom notes, "The design principles are not blueprints. . . . They describe the broad structural similarities among those self-organized systems that have been able to adapt and learn so as to be robust to the many social, economic and ecological disturbances that occur over time."

Source: Elinor Ostrom, *Understanding Institutional Diversity* (Princeton, N.J.: Princeton University Press, 2005). © 2005 by Princeton University Press. Reprinted by permission of Princeton University Press.

devising and enforcing stable social norms and formal rules for cooperative natural resource management and even restoring cooperation after it has broken down. However, vigilance is needed because the underlying incentives for defection remain. In fact, as development proceeds, there are generally greater opportunities and incentives for individuals to appropriate common property for their own use, so in some cases, increased vigilance and external support could play a vital role; a subset of common property systems will be unlikely to endure.[33]

Public Goods and Bads: Regional Environmental Degradation and the Free-Rider Problem

Externality Any benefit or cost borne by an individual economic unit that is a direct consequence of another's behavior.

Internalization The process whereby external environmental or other costs are borne by the producers or consumers who generate them, usually through the imposition of pollution or consumption taxes.

Public good An entity that provides benefits to all individuals simultaneously and whose enjoyment by one person in no way diminishes that of another.

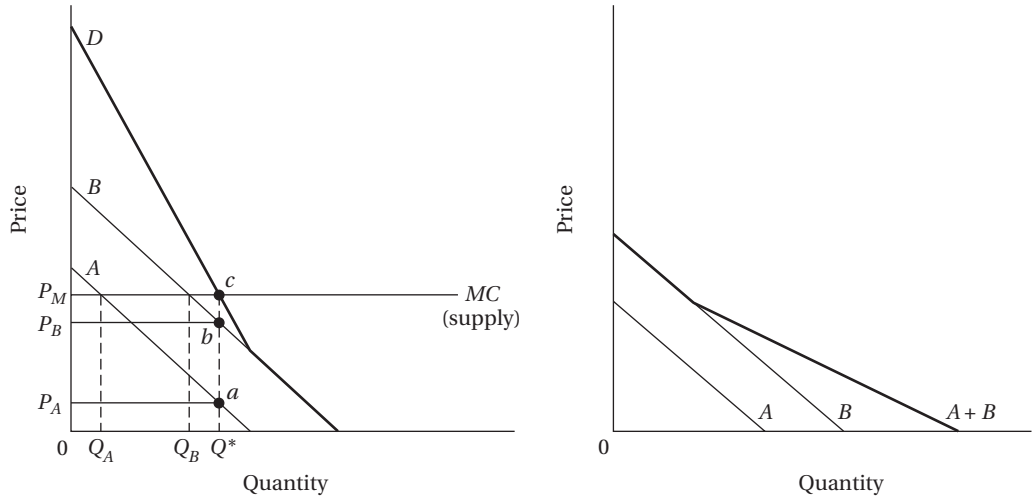
Public bad An entity that imposes costs on groups of individuals simultaneously. Compare public good.

In the preceding discussion, the core economic problem was that each additional worker who joined those cultivating commonly held land created a negative **externality** by lowering the returns to all other workers without providing any compensation. An externality occurs when one person's consumption or production behavior affects that of another without any compensation. The benefits and costs of one's actions are said to be internalized when one is made to bear them in full. In the previous common property problem, the externalities associated with decreasing average product were easily internalized by reestablishing perfect property markets through the privatization of public property. In many cases, the **internalization** of externalities is not so easily accomplished. This is especially the case where the consequences of an individual's actions constitute a public good or a public bad. A **public good** is anything that provides a benefit to everyone and the availability of which is in no way diminished by its simultaneous enjoyment by others. Common examples include clean air, economic institutions, and national defense. A **public bad** is any product or condition that decreases the well-being of others in a nonexhaustive manner. Air pollution and water pollution are examples. Intuitively, it is clear that given the fact that individuals do not pay the full costs associated with their actions, too much of a public bad will be produced. The result is a socially nonoptimal outcome. We will demonstrate this shortly using a diagrammatic representation. Public goods can be local, national, or, as with greenhouse gases, even global in scope.[34]

Let us consider the case of a particular public bad, regional environmental degradation caused by deforestation. Increased exposure to the forces of erosion, excessive drying of the soil, regional loss of groundwater, silting or pollution of public water supplies, and potential climatic changes are all public bads associated with the clear-cutting or burning of trees. Whether these trees are on private or commonly held property, the clearing of protective ground cover, either for cultivation or for the extraction of timber, may lead to more widespread regional environmental degradation. To simplify our analysis, we will translate this public-bad problem into a public-good framework. Environmental conservation through the protection of trees provides a benefit to all and is thus a public good.

The most obvious difference between a public good and a purely private good is that aggregate demand for the public resource is determined by summing

FIGURE 10.4 Public Goods, Private Goods, and the Free-Rider Problem



(a) Public good (vertical summation)

(b) Private good (horizontal summation)

individual demand curves vertically, as in Figure 10.4a, rather than horizontally, as is the case for private goods as illustrated in Figure 10.4b. The difference results from the fact that many individuals may enjoy the same unit of a public good but only one may benefit from a unit of a normal, private-consumption good. Through vertical summation, we are sure to capture all benefits accruing to all individuals from each unit of a public good. The marginal cost associated with the preservation of an additional tree is equal to the forestry maintenance cost plus the opportunity cost of the tree, that is, the most valuable alternative use of the tree, such as for firewood, charcoal, animal fodder, or lumber. Figure 10.4 illustrates the problem of pricing public goods.

In Figure 10.4a, the socially optimal number of trees is Q^*. It is determined by the intersection of the (vertically summed) aggregate demand curve with the supply (MC) curve. At Q^*, total net benefits to society from the public good, $P_M Dc$, are maximized. However, due to what we call the **free-rider problem**, the free market will not lead to this optimal quantity. Because individuals are able to enjoy the benefits of trees provided by others, each will contribute less than what he or she would if acting independently. At a price of P_M, the free market will satisfy person B's demand Q_B while not denying person A's requirements of Q_A; that is, A can free ride on B's contribution. The market will therefore provide a suboptimal level of forest preservation, Q_B. To restore optimality (Q^* of the public good), some form of government intervention is required. The most effective solution is to charge each consumer just enough per unit, P_A and P_B for individuals A and B, respectively, to entice each of them to demand the preservation of the optimal quantity of trees, Q^*. Their joint payments, $P_A \times Q^*$ for A plus $P_B \times Q^*$ for B, represent a total contribution equal

Free-rider problem The situation in which people can secure benefits that someone else pays for.

to $P_M \times Q^*$, exactly the sum required to purchase the socially optimal level of preservation.

Limitations of the Public-Good Framework

The problem with the public-good pricing mechanism is, of course, how to know which prices to charge. People have no incentive to divulge how much they really benefit from a public good because by shirking, they may free-ride on the contributions of others and avoid paying their full share. A government may be capable of reducing market inefficiencies, but it is unlikely to be able to produce a perfect allocation of resources due to deficiencies in the information available to it. Hypothetically, collected fees can be used to provide a public good by preserving existing forests or managing a sustainable timber production program that will supply the community's needed timber. Although charging fees to the people benefiting from the preservation of a resource may sound practical, it is exceedingly difficult. In a development context, the problems become even more complicated. When the collection of fees entails taxing deeply impoverished populations with little or no cash income, such a program becomes an impossibility. It would be equally difficult to collect payment from people who are cutting trees to meet subsistence needs. However, neoclassical theory can be useful for explaining why market failures lead to the inefficient allocation of resources in highly commercialized economies and how these inefficiencies may be mitigated.

10.5 Urban Development and the Environment

Environmental Problems of Urban Slums

In some ways, life among the poor in urban slums is similar to that of the poor in rural villages: Families work long hours, income is uncertain, and difficult trade-offs must be made between expenditures on nutrition, medical care, and education. Though on average, urban dwellers are likely to have higher incomes, the poorest are frequently at greater risk of being exposed to dangerous environmental conditions. Let us contrast our earlier look at environmental conditions in an African and a South American rural community with those of an Asian urban shanty.

In a typical urban slum in an Asian metropolis, health-threatening pollutants are commonplace both inside and outside the home. Many women are unaware that the smoke from the fuels they burn in the home to cook and boil water may have severe long-term consequences for the health of their children (though public health programs and NGOs have recently been encouraging cooking with better alternatives, with some success). Conditions resulting from poor ventilation in the home can be equivalent to smoking several packs of cigarettes per day, and women and their children are exposed to these fumes for long portions of each day. Though some children actually avoid much of this exposure by attending school, many are kept out of school to assist their mothers in market work or the production of goods at home. Thus from an early age, chronic and acute bronchitis is a cruel fact of life. Debilitating and ultimately fatal respiratory infections among the poor are commonplace.